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PROGRESS REPORT

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DIRECT MEASUREMENTS OF TROPOSPHERIC OZONE FROM TOMS RADIANCES

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ABSTRACT

Measurements of the global tropospheric ozone fields are of great importance for a full understanding of the chemical and dynamical processes that control the distribution and amount of trace gases in the troposphere and stratosphere. In previous work we have shown that tropospheric ozone amounts can be retrieved directly from the radiance data obtained by TOMS (Total Ozone Mapping Spectrometer), and that the use of TOMS archived ozone amounts can lead to large errors. This new algorithm was applied to the Biomass Burning regions of Africa, and daily maps of the tropospheric ozone were obtained. The specific objectives of this investigation are (1) to develop the equatorial algorithm further and to extend the analysis to cover the entire African continent, (2) to apply the algorithm to the study of the climatology of the biomass burning seasons (3) to develop a new technique for the derivation of a climatological tropospheric ozone data base using cloud to ground radiance differences and (4) to study the global trends of the zonally averaged tropospheric ozone from 1988 to 1993.

SUMMARY OF PROGRESS AND RESULTS

In 1994 we developed a new algorithm to obtain tropospheric column ozone amounts directly from the TOMS measured albedos. These albedos are archived on the High Density TOMS data tapes (the HDT tapes). We were able to obtain maps at a spatial resolution of about 50 km square, which is approximately 6 times more dense than the Grid-T TOMS product. This technique was applied to the tropical eastern Atlantic, the adjacent African continent, and the Indian Ocean, during the biomass burning season in 1989. The analysis was restricted to latitudes between 10 degrees N and 10 degrees S, in order to minimize variations in the stratospheric ozone.

In 1995 we increased the spatial extent of the algorithm to the entire tropical zone (Kim, 1995, and Kim et. al. 1996). To increase the accuracy of the derived tropospheric ozone, 15 day averages of the data were examined. The initial work was performed for the month of October 1992, for which time there were extensive sonde and aircraft measurements (TRACE-A Mission). An apparent longitudinal wave-one structure was identified in the total ozone field, with a maximum at 0 degrees longitude, and a minimum at 180 degrees. The peak to peak value of the wave was 13 DU. If the wave-one pattern was ascribed to the stratosphere, then good agreement was obtained between the tropospheric column obtained from our algorithm, and that derived from the sonde and aircraft measurements. It should be noted however, that this conclusion is in apparent disagreement with the profile data from the SAGE and MLS instruments.

This year we have extended the analysis to the first fifteen days of all the months of 1992, and find that the wave-one pattern is persistent for the entire year, and comparisons with sonde data are consistent with the pattern being in the stratosphere. (Hudson and Thompson, 1996). We have now begun to apply the same algorithm to the entire Nimbus-7 data base from 1978 to 1993. As of this time, we have completed the stripping of the data from the HDT TOMS archives, and have tropopsheric ozone plots for the first three years. We should therefore fulfill our goal of having 15 day average monthly tropospheric for all years by the end of the investigation,. The eventual aim is to produce an archival data set for the use of other investigators.

We have also begun producing daily tropospheric ozone maps for the tropics from radiances from the EP/TOMS and the ADEOS/TOMS. These plots are placed in the Department of Meteorology Home Page, but will be linked with the GSFC TOMS Home Page, for easy access by any outside investigator. For these plots we have adopted a similar approach to that for the monthly fifteen day averages except that we now obtain the stratospheric ozone field from an analysis of the total ozone for a period of five days before the day chosen These daily maps will be available for aircraft missions in 1997.

The methods described above work only in the tropics, where the stratospheric field is smooth and can be assumed to be only a function of latitude. At mid to high latitudes the zonal ozone fields are much more variable. A large proportion of this variablility is due to averaging over different air masses at the same latitude, e.g. polar air masses frequently come down into mid latitudes, and tropical air masses up into the polar regions. We have examined the variability in each air mass and find it much smaller, leading to the possibility that we can apply the same techniques to obtain tropospheric ozone at mid to high latitudes, by limiting the analysis to a particular air mass.

We have continued our investigation of another method, which looks at radiances obtained above clouds with a large enough dimension to fill the field of view of TOMS, and those obtained from a contiguous pixel of clear sky, or a cloud at a different altitude. Calculations have shown that the ratio of the radiances is relatively independent of the stratospheric column, thus obviating the need for accurate estimates of this quantity. .To perform a preliminary analysis of the method, we obtained a sample of data from the new high resolution ISCCP cloud data set. The month we selected was Oct. 1990, and we chose the geo-synchronous satellite which was centered over the Mid-Atlantic, i.e. a period which should correspond to the biomass burning season, This should maximize our chance of seeing tropospheric ozone. .We have generated a new set of look-up tables based on the DISSORT radiative transfer code. The biggest difficulty has been to identify those pixels with total cloud cover., for a low reflectivity total cloud could just as well be a partial cloud. with high reflectivity. We have developed a method using the visible and infra-red optical depths given in the ISCCP data set to aid in this identification. As long as we limit the analysis to high clouds then the results we obtain for the tropospheric column ozone are encouraging. They are consistent with those obtained from the method discussed in previous paragraphs. However, the method for medium to low clouds shows a wide scatter in the results. We believe that this is due to the fact that low clouds often have irregular shapes, and are frequently partial rather than continuous. We have noted that ozone amounts obtained at high scan angles seem to show much less variability, when the effect of broken clouds will be much less due to shadowing. We are continuing with this analysis.

JOURNAL PUBLICATIONS

Robert D. Hudson and Jae-Whan Kim, "Direct Measurements of Tropospheric Ozone using TOMS Data", in 'Ozone in the Tropopshere and Stratosphere', Proceedings of the Quadrennial Ozone Symposium, 1992, NASA Tech.Rep., 1994.

Robert D. Hudson, Jae-Hwan Kim and Anne M. Thompson, 'On the Derivation of Tropospheric Ozone from Radiances Measured by the Total Ozone Mapping Spectrometer', J. Geophys Res., 100, 11137- 11145, 1995.

A.M.Thompson, K.E. Pickering, D.P. McNamara, M.R. Schoeberl, R.D. Hudson, J.H. Kim, E.V. Browell, V.W.J.H. Kirchoff, and D. Nganga, 'Where did tropospheric ozone over southern Africa and the tropical Atlantic come from in October 1992? Insights from TOMS, GTE, TRACE A, and SAFARI 1992', J. Geophys. Res., 101, 24300-24316, 1996.

J.H. Kim, R.D. Hudson, and A.M. Thompson, 'A new method of deriving time averaged tropospheric ozone over the tropics using total ozone mapping spectrometer radiances:-: Intercomparison and analysis using TRACE A data', J. Geophys. Res., 101, 24317 - 24330, 1996.

PROPOSED ACTIVITIES

The research for the next year is composed of three parts:-

(1) Continue the analysis of the 15 day monthly averages for the entire Nimbus-7 data set. One aspect of the research will be to examine the 'wave-one pattern' under different tropospheric dynamic regimes, i.e. El-Nino vs non El-Nino years. Another is to examine the climatology of bio-mass burning through wet and dry years.

(2) To continue the analysis of the tropical ozone technique to higher latitudes.

(3) To continue the development of the cloud to ground technique. To begin to develop a climatology of tropopsheric column ozone using this technique, although progress in this area will depend on the availability of the high resolution ISCCP data.